EEE 313 - Electronic Circuit Design - Lab 4 Preliminary Report
Tuna Şahin - Wide-Band Amplifier

1 - Introduction:

In this lab we were asked to implement a two-stage wide-band amplifier with feedback. Due to the feedback, the gain of the amplifier is stable and not 'β' dependent.

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2 - Calculations:

I arbitrarily chose $I_{C1} = 9mA$ and $I_{C2} = 33mA$ at DC to leave room for the current swing at AC so it is less than 70mA. (We need $V_{E1} = V_{E2} \simeq 1V$)

We need to choose $R_1, R_3, R_4, R_5, R_6, R_8$ biasing resistors to obtain these values.

By writing the mesh for the base emitter line of the first transistor:

$I_{C1}\frac{R_1}{\beta} + R_2 I_{C1} = 12 - V_{BE} \Rightarrow 9m = \frac{11.4}{R_1/400 + R_2}\ (i)$ We obtain a solution: $R_1 = 390k,\ R_4 = 47$

For the second transistor:

$V_{TH} = 12\frac{R_6}{R_5+R_6}$ and $R_{TH} = R_5 \parallel R_6$ $\qquad V_{TH} - \frac{I_{C2}}{\beta}R_{TH} - V_{BE} - I_{C2}R_8 = 0\ (ii)$

We get a solution as: $R_5 = 3900,\ R_6 = 820,\ R_8 \simeq 40$

Gain resistors are chosen as $R_9 = 560$ and $R_4 = 47$ which give a ratio of approximately 12.

Emitter bypass capacitor $C_4 = 220\mu$ from the formula $X_{C4} = R_8 \parallel (\frac{1}{g_{m2}})$

All of the bypass capacitors are chosen as $10\mu F$.
Collector resistors are chosen as their maximum value where the wave does not saturate.

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3 - LTSpice Schematic:

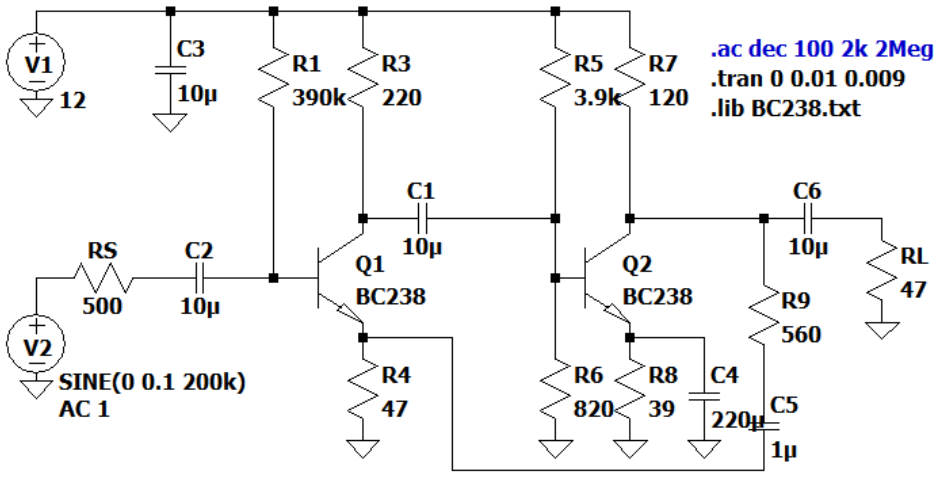

Figure 3: LTSpice Schematic

(i) One equation, two variables. Arbitrarily chose 390k for R1
(ii) One equation, three variables. Arbitrarily chose R5 and R6

4 - LTSpice Simulations:

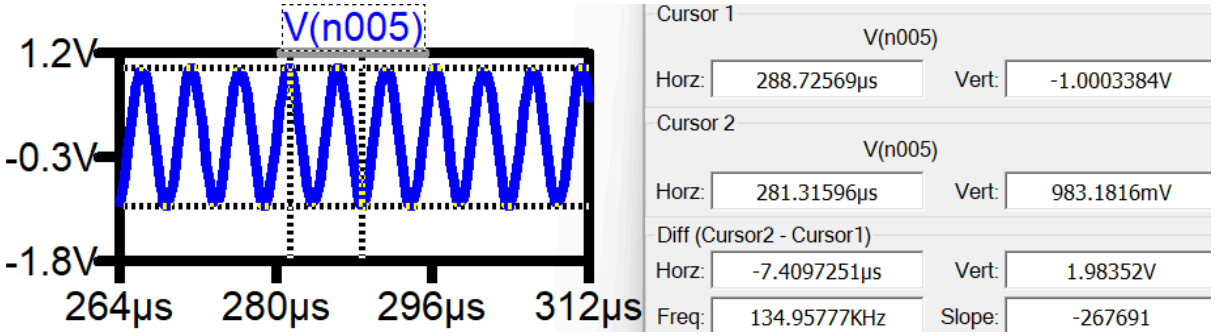

Figure 4.1: $V_{out} = 1.98V_{pp}$ when $V_{in} = 0.2V_{pp}$ (Gain = 19.91dB)

Specification 1: The current consumption is less than 70mA

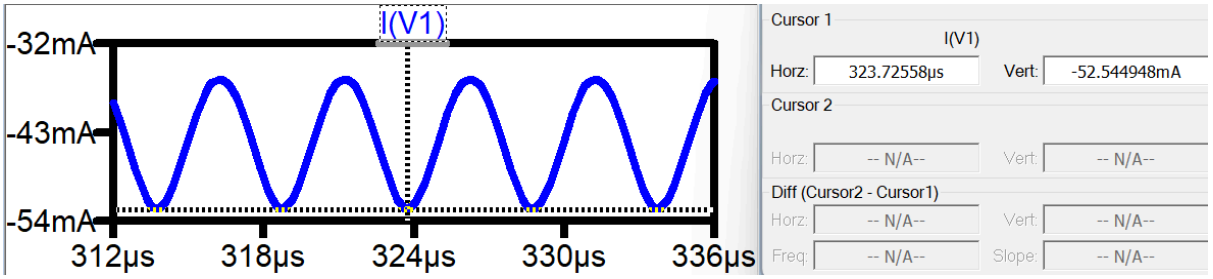

Figure 4.2: Peak Source Current Observed to be 52.5mA

Specification 2: The small-signal bandwidth is at least 2KHz-2MHz while the mid-band gain is 20dB±0.5dB (by AC analysis)

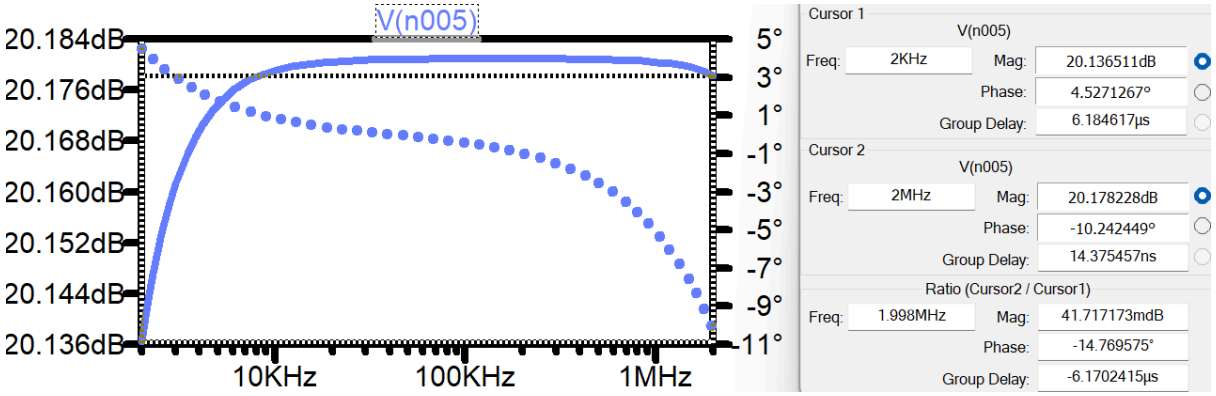

Figure 4.3: -3dB Bandwidth is found to include 2kHz-2MHz
(AC Sweep Settings: 200Hz - 20MHz)

Specification 3: The harmonic content of the output voltage is better than −30dBc with 0.1V peak input signal at 200KHz

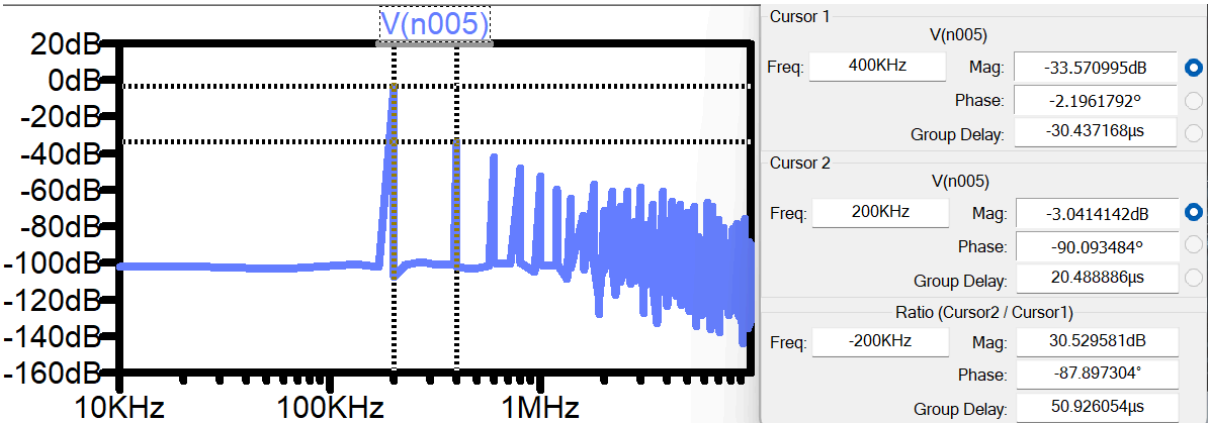

Figure 4.4: The Highest Harmonic (2rd) is 30.5dB Lower than the fundamental harmonic.

Determination 1: The small-signal input impedance of the amplifier at 200KHz (the adjusted value of RS in AC analysis until the voltage gain drops by 6dB compared to RS=0)

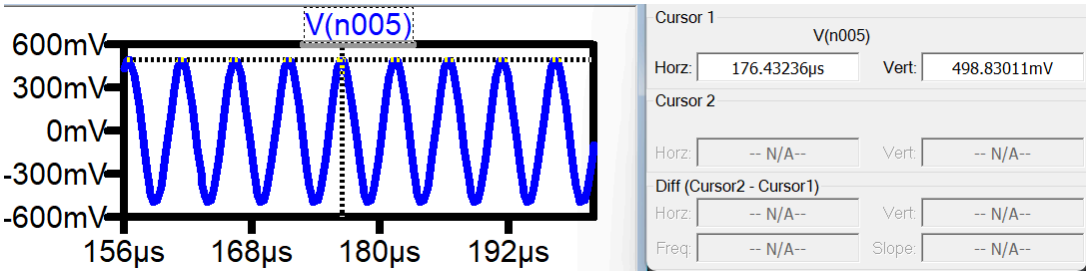

Figure 4.5: The gain is 14dB when $R_S = 60k$ ($V_{in} = 0.2V_{pp}$ and $V_{out} = 1V_{pp}$)

Determination 2: The small-signal output impedance of the amplifier at 200KHz (the adjusted value of RL in AC analysis until the voltage gain drops by 6dB compared to RL=∞)

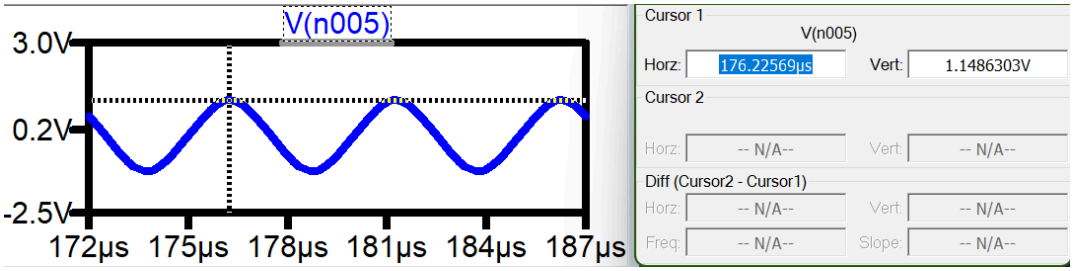

Figure 4.6.1: Gain = 21.21dB when $R_L = \infty$($V_{out} = 2.3V_{pp}$ and $V_{in} = 0.2V_{pp}$)

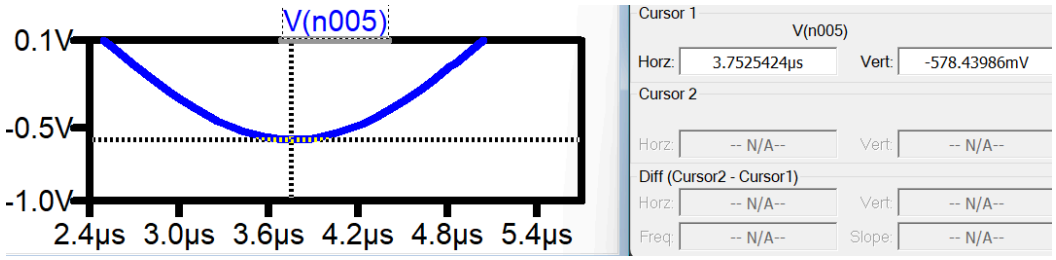

Figure 4.6.2: Gain = 15.23dB when $R_L = 9$($V_{out} = 1.156V_{pp}$ and $V_{in} = 0.2V_{pp}$)

Determination 3: The phase margin of the open-loop system.

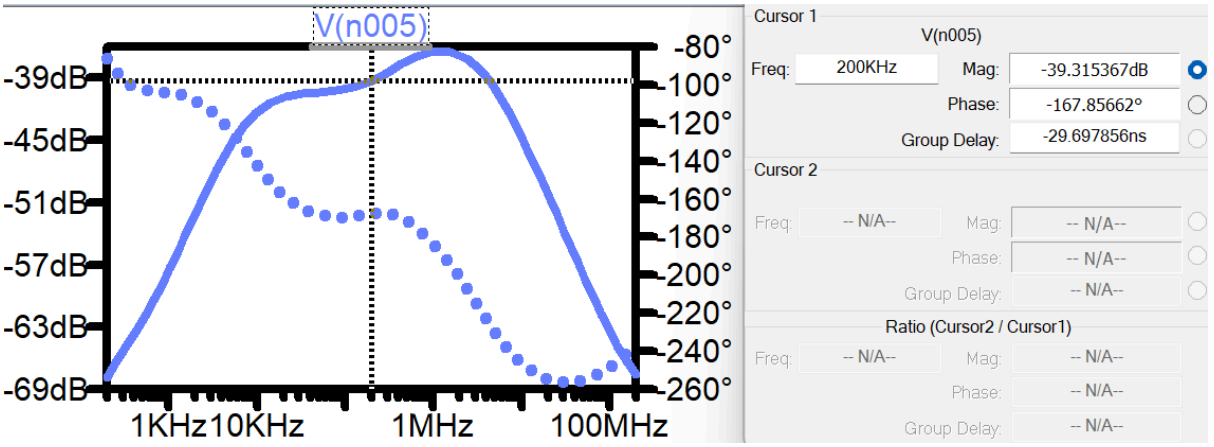

Figure 4.7: Phase Margin is found to be 200 degrees.

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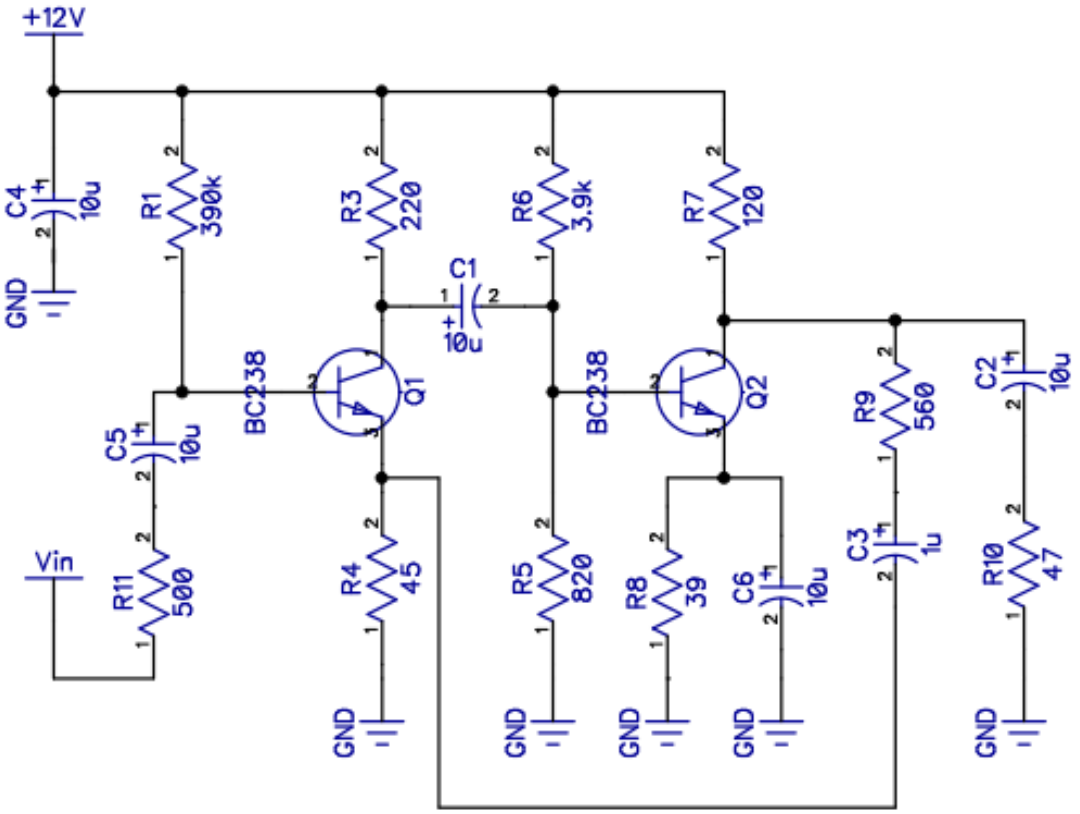
5 - Conclusion

To summarise, we were asked to design a two-stage amplifier that had to satisfy some criteria. The amplifier I designed has a band (-3dB) between 16MHz and 74Hz. That interval includes the desired band of 2kHz to 2MHz. The amplifier had a 50mA current consumption which is less than the upper limit of 70dB. And the amplifier's output had a 30.5dB difference between the fundamental harmonic and the second highest harmonic.

- The maximum value of RS that had -6dB of gain was found to be 60kΩ.
- The minimum value of RL that had -6dB of gain was found to be 9Ω
- The phase margin of the open-loop system was found to be 200 degrees

6 - Diptrace Schematic:



#	Name	Quantity	Value	RefDes
1	Cap, Electrolytic, 300mil	4	10u	C1, C2, C4, C5
2	Cap, Electrolytic, 300mil	1	1u	C3
3	Cap, Electrolytic, 150mil	1	10u	C6
4	BC238	2	BC238	Q1, Q2
5	Resistor320	1	390k	R1
6	Resistor320	1	220	R3
7	Resistor320	1	45	R4
8	Resistor320	1	820	R5
9	Resistor320	1	3.9k	R6
10	Resistor320	1	120	R7
11	Resistor320	1	39	R8
12	Resistor320	1	560	R9
13	Resistor320	1	47	R10
14	Resistor320	1	500	R11

Figure 5: DipTrace Schematic and Component List